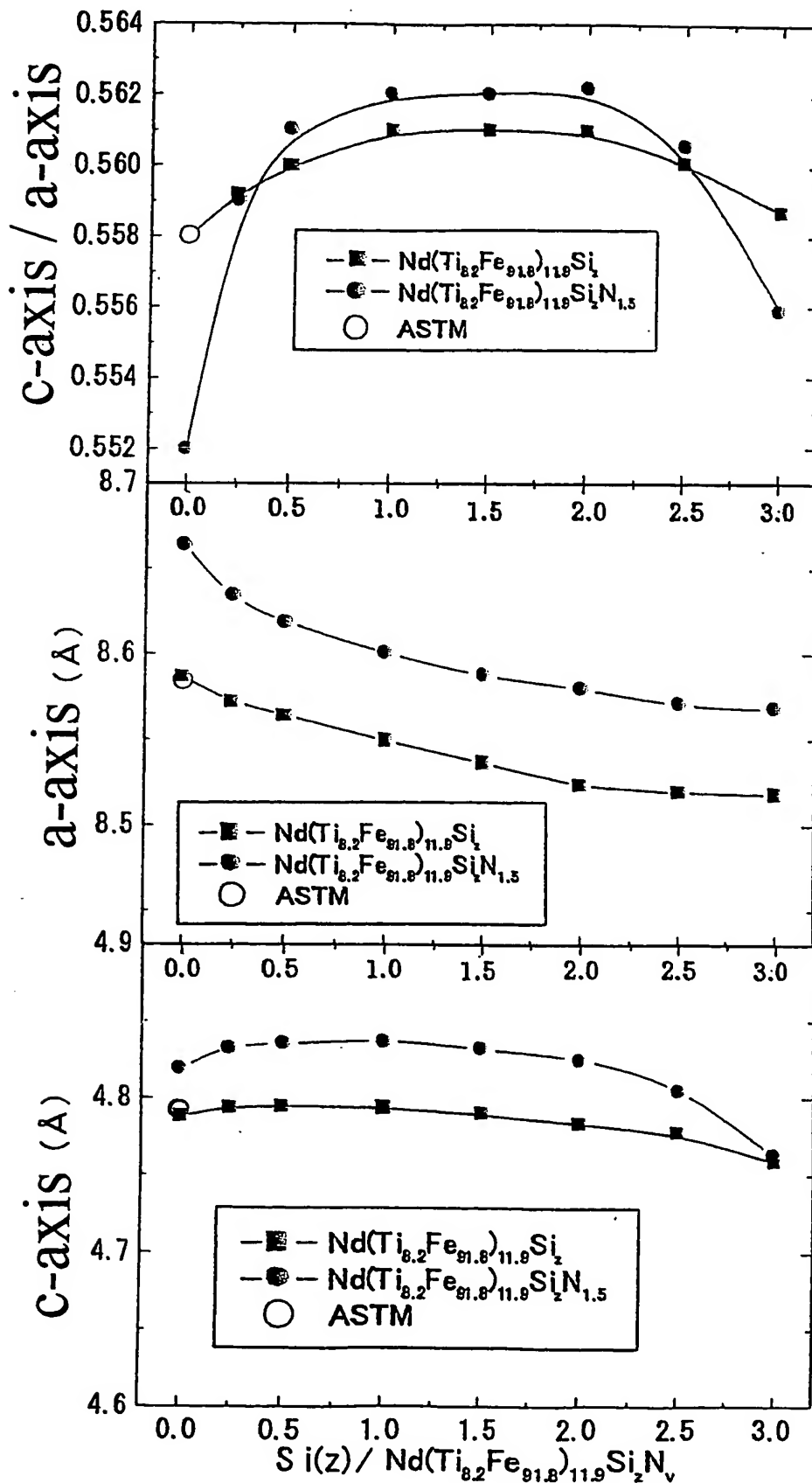


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Figure 1



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Figure 2

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
1	8.3	11.9	0.2	1.6	0	143.8	51.5	12.1	8.0	Single phase (only 1-12 phase)
2	8.2	11.9	0.5	1.5	0	143.5	52.1	12.4	7.5	
3	8.2	12.1	1.0	1.5	0	140.8	55.4	13.1	6.6	
4	8.2	12.0	1.5	1.3	0	138.2	58.2	13.5	5.8	
5	8.1	11.9	2.0	1.4	0	136.8	59.8	13.9	4.9	
6	8.3	12.1	0	1.4	0	141.8	28.9	12.1	8.3	1-12 Phase, 2-17 phase, α -Fe phase
7	8.3	12.1	2.5	1.4	0	129.5	35.7	14.6	4.1	1-12 Phase, α -Fe
8	8.2	9.8	2.5	1.5	0	115.2	29.8	12.3	4.1	Single phase (only 1-12 phase)

Figure 3A

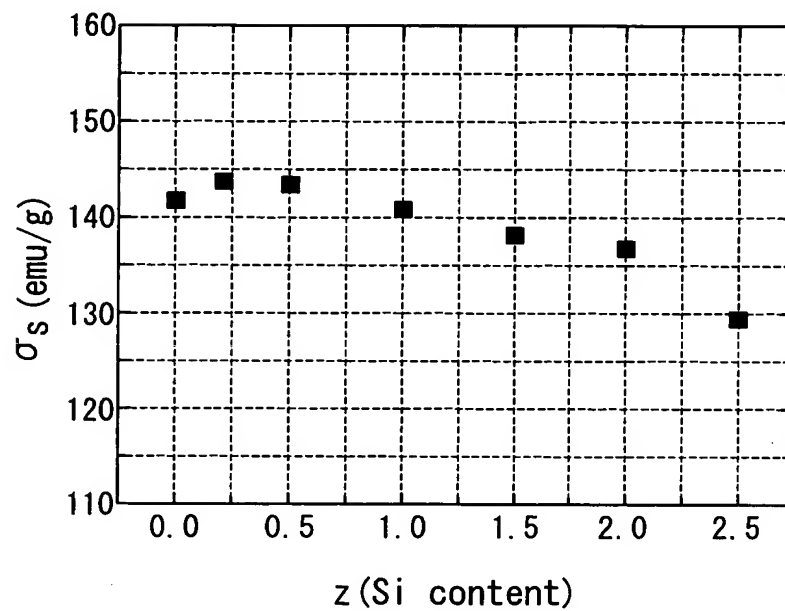
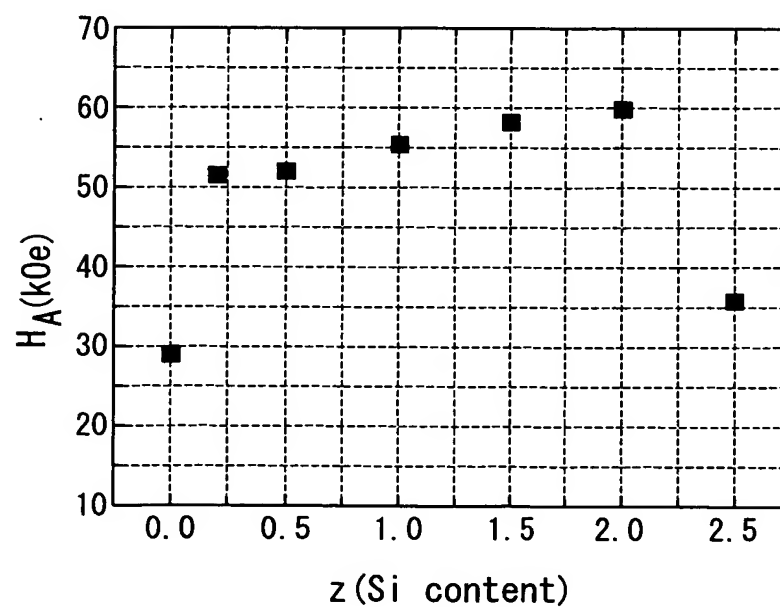


Figure 3B



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Figure 4

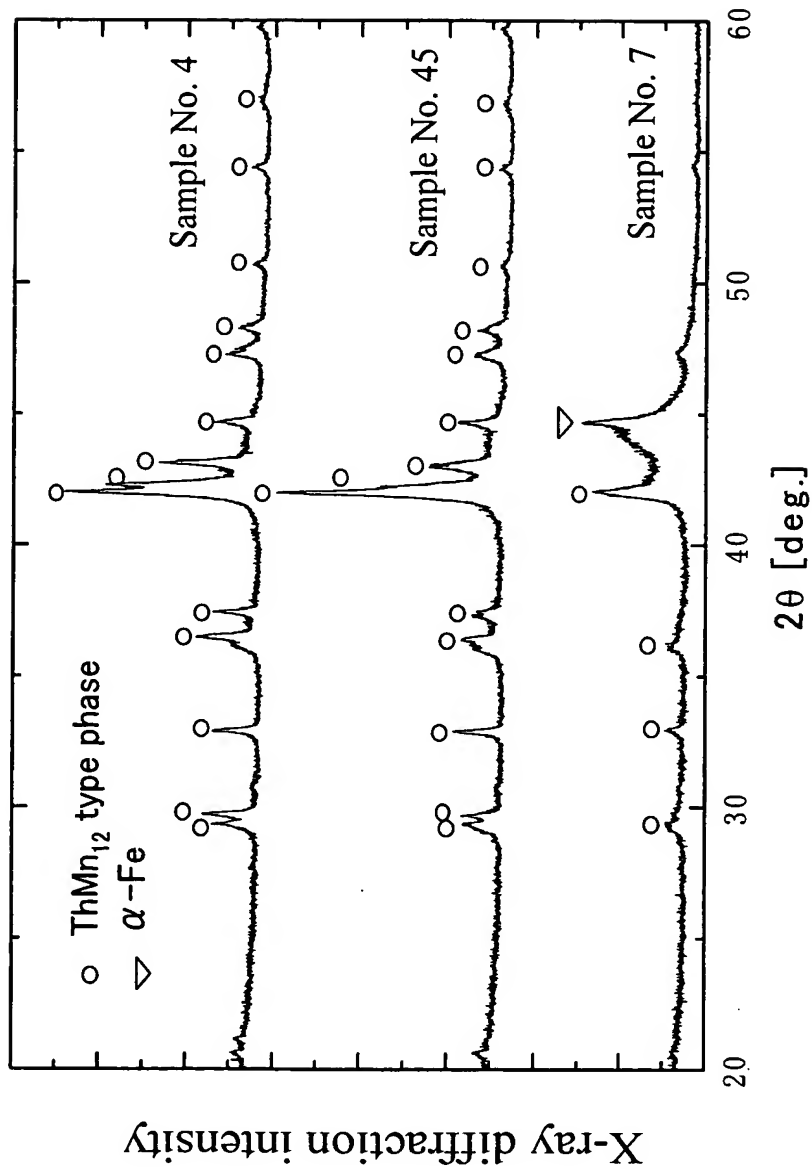
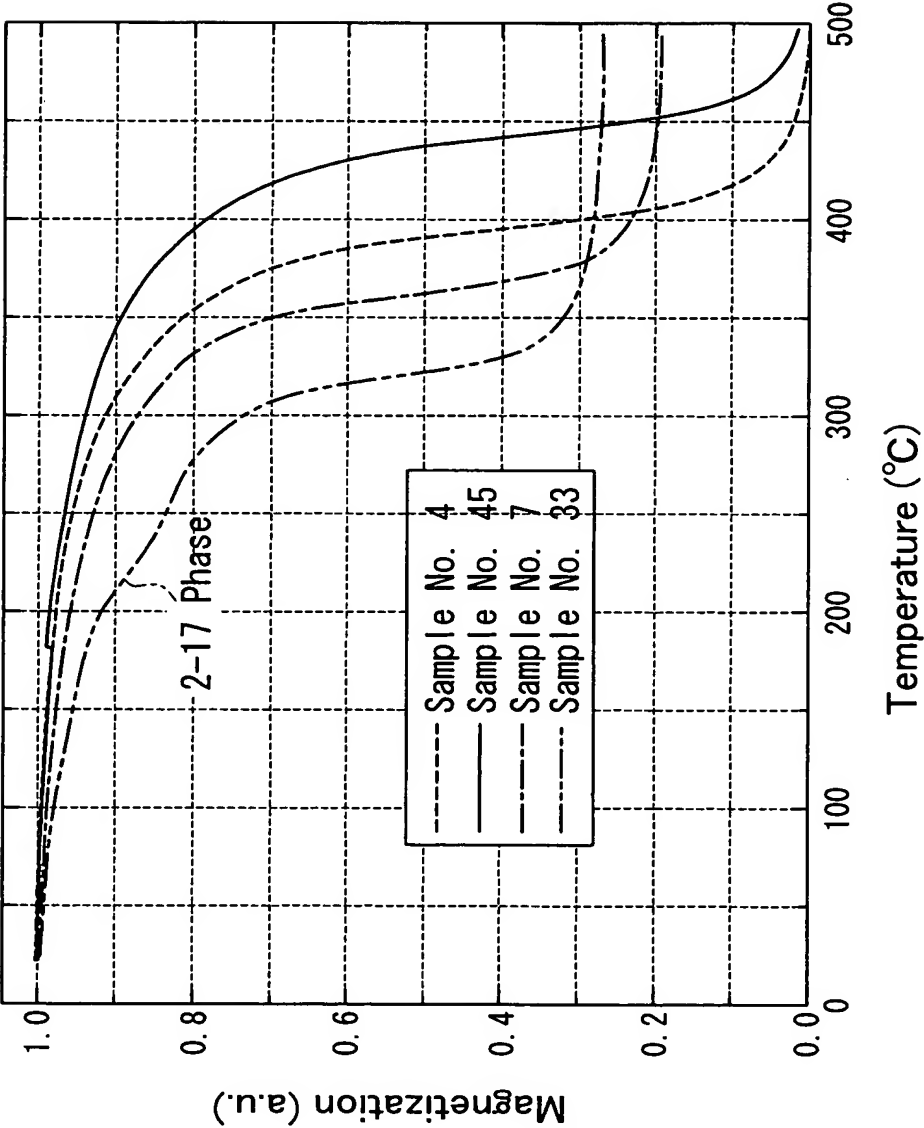


Figure 5



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Figure 6

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
9	8.0	11.2	1.0	1.6	0	130.0	54.6	12.2	6.6	Single phase (only 1-12 phase)
10	8.3	12.2	1.0	1.5	0	142.7	55.1	13.2	6.6	
11	8.3	12.5	1.0	1.5	0	145.2	54.9	13.5	6.6	
12	8.2	10.1	2.0	1.6	0	121.6	57.4	12.1	4.9	
13	8.1	10.5	1.9	1.5	0	124.8	59.0	12.4	5.1	
14	8.1	10.9	1.9	1.5	0	127.4	58.6	12.8	5.1	
15	8.0	12.2	2.0	1.4	0	135.9	58.9	14.2	4.9	
16	8.2	12.5	2.0	1.5	0	138.2	58.4	14.5	4.9	
17	8.3	9.5	1.1	1.5	0	116.8	30.2	10.6	6.4	Single phase (only 1-12 phase)
18	8.3	10.0	1.0	1.4	0	118.0	32.0	11.0	6.6	
19	8.2	10.5	1.0	1.5	0	119.2	33.9	11.5	6.6	
20	8.3	12.7	1.0	1.6	0	145.9	46.2	13.7	6.6	1-12 Phase, α -Fe
21	8.1	9.5	2.0	1.6	0	114.8	49.5	11.5	4.9	Single phase (only 1-12 phase)
22	8.3	12.7	2.0	1.6	0	137.8	45.8	14.7	4.9	1-12 Phase, α -Fe

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Figure 7A

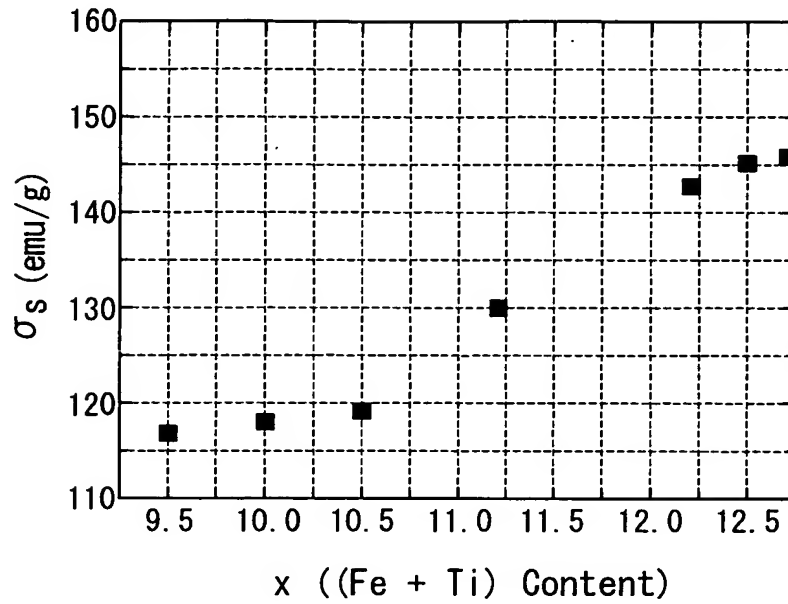
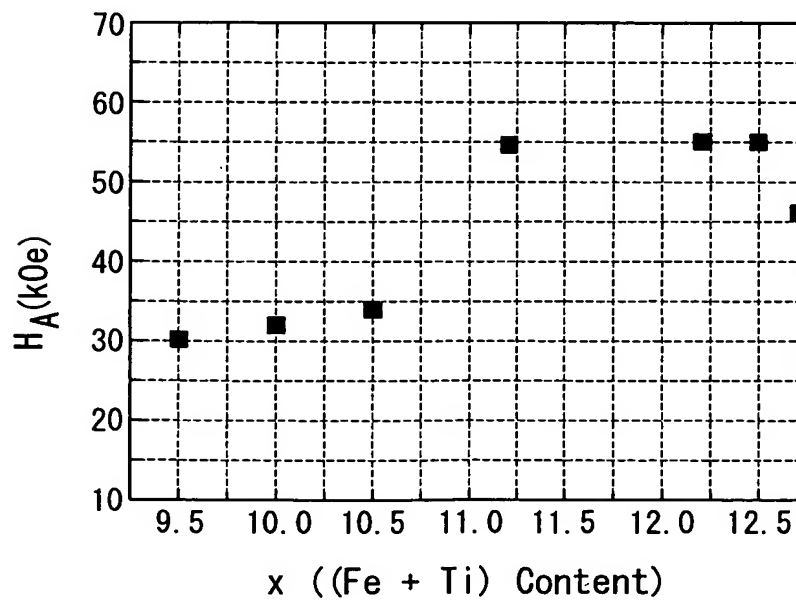


Figure 7B



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Figure 8A

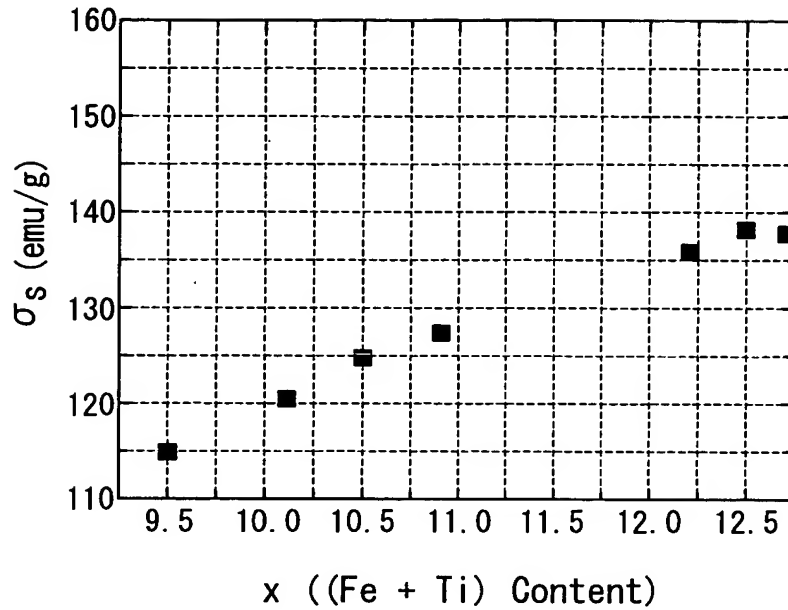


Figure 8B

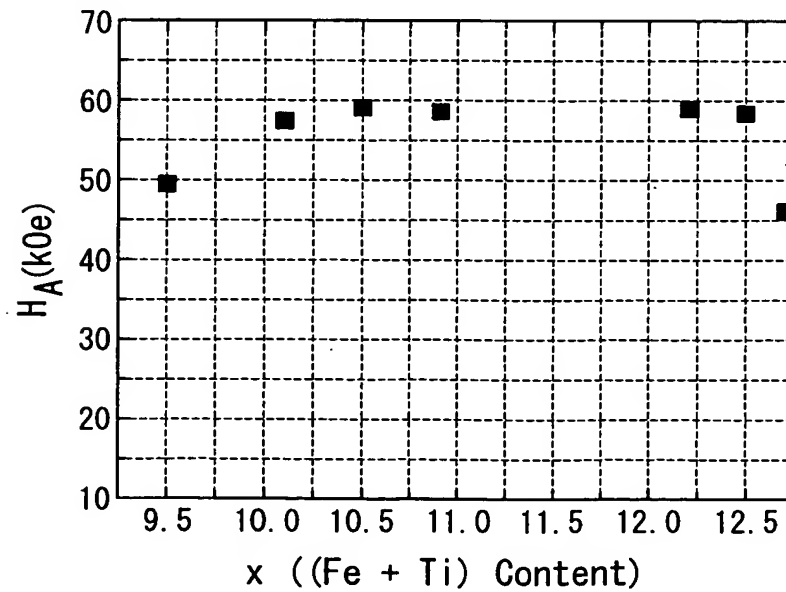


Figure 9

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
23	6.6	12.1	1.0	1.3	0	145.0	57.1	13.1	6.6	Single phase (only 1-12 phase)
24	7.5	12.1	1.0	1.5	0	143.8	57.0	13.1	6.6	
25	10.0	11.9	1.0	1.5	0	135.1	50.3	12.9	6.6	
26	5.8	12.2	1.5	1.4	0	146.2	62.0	13.7	5.8	
27	6.7	12.0	1.5	1.4	0	143.0	61.8	13.5	5.8	
28	7.5	11.9	1.5	1.5	0	141.2	60.4	13.4	5.8	
29	4.9	11.9	2.0	1.4	0	142.5	63.8	13.9	4.9	
30	5.8	12.1	2.0	1.4	0	142.0	63.0	14.1	4.9	
31	6.7	12.0	2.0	1.5	0	141.9	62.8	14.0	4.9	1-12 Phase, 2-17 phase, α -Fe phase
32	7.5	11.9	2.0	1.5	0	139.5	61.1	13.9	4.9	
33	5.0	12.0	1.0	1.5	0	138.2	29.0	13.0	6.6	
34	5.8	12.1	1.0	1.5	0	139.7	41.6	13.1	6.6	
35	12.5	12.2	1.0	1.4	0	118.0	44.1	13.2	6.6	
36	4.2	12.0	1.5	1.5	0	128.5	29.5	13.5	5.8	
37	5.0	12.2	1.5	1.5	0	135.0	45.3	13.7	5.8	
38	3.3	12.1	2.0	1.5	0	135.8	52.8	14.1	4.9	1-12 Phase, α -Fe

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Figure 10A

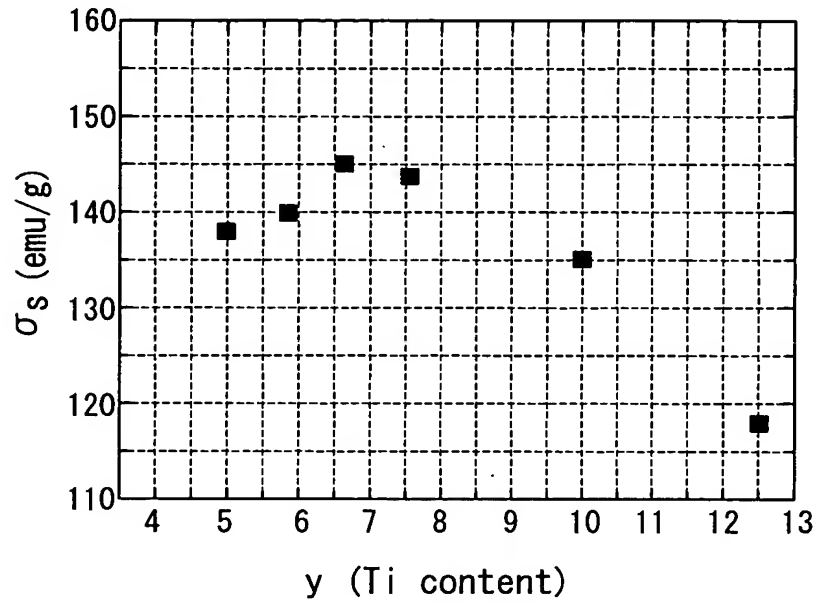


Figure 10B

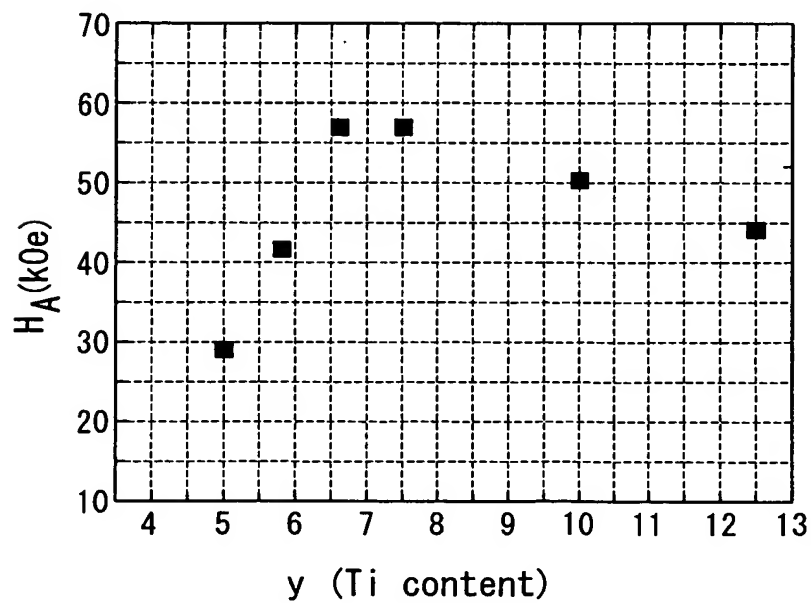


Figure 11A

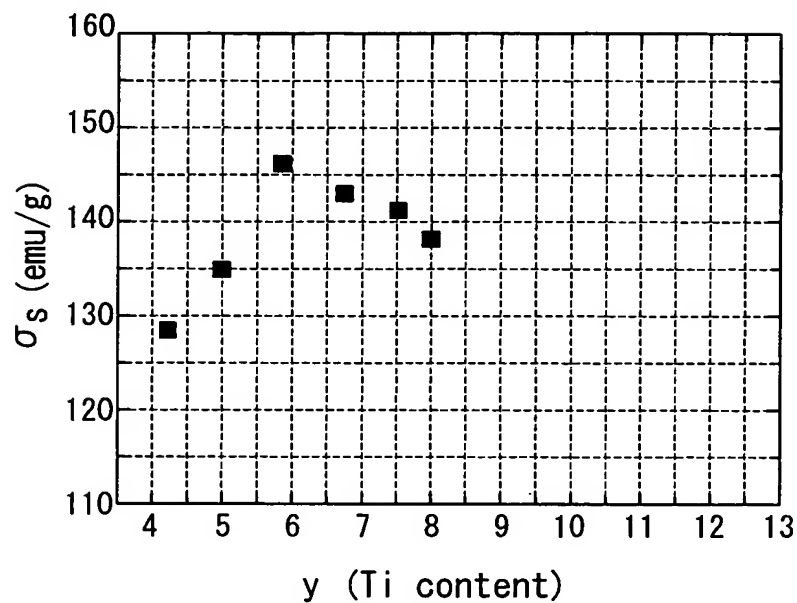
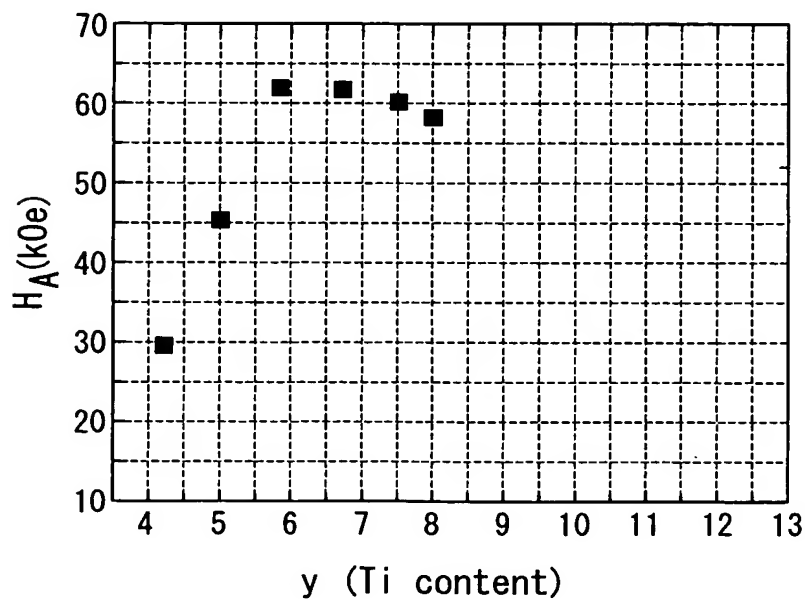


Figure 11B



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Figure 12A

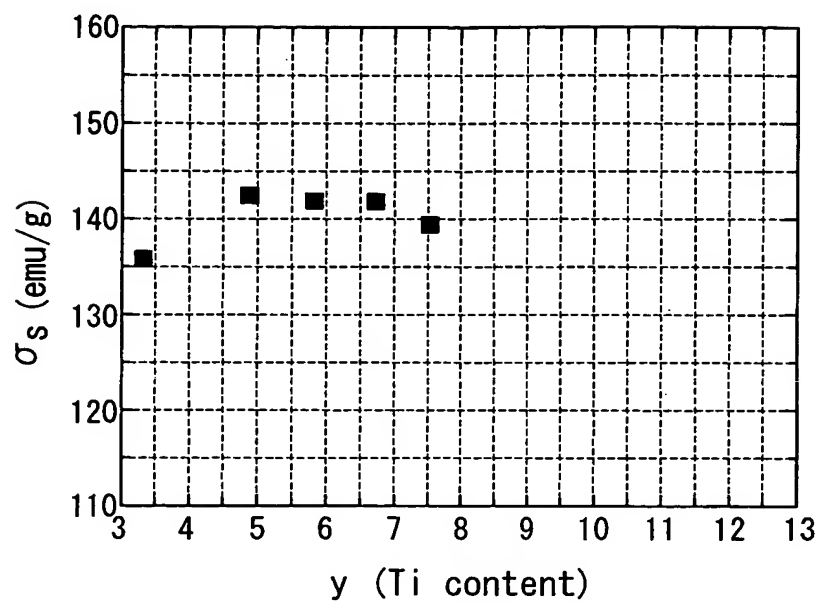
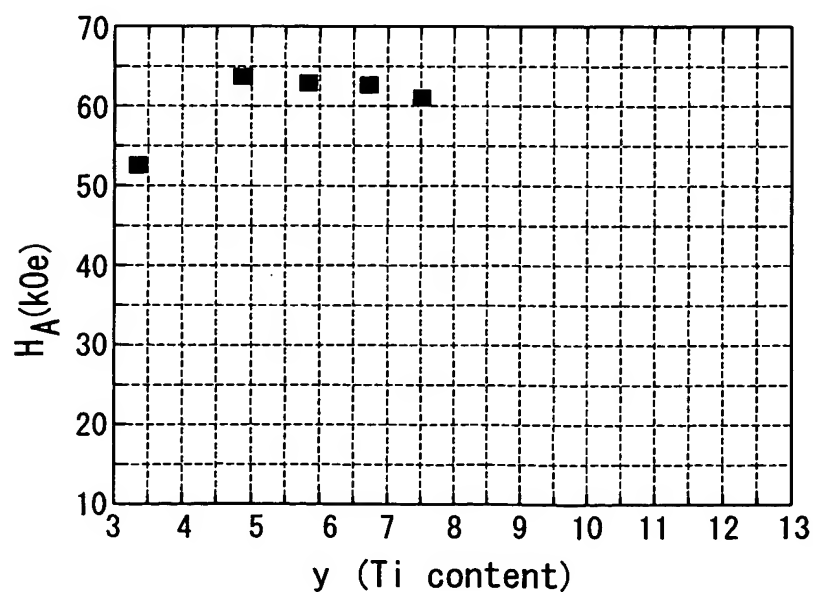


Figure 12B



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Figure 13

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	σ s [emu/g]	HA [kOe]	Fe+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
39	8.3	12.2	1.1	0.4	0	125.2	35.2	13.3	6.4	Single phase (only 1-12 phase)
40	8.2	12.0	1.1	1.0	0	134.2	45.9	13.1	6.4	
41	8.2	11.9	1.0	1.9	0	139.8	56.8	12.9	6.6	
42	8.1	11.9	1.0	2.5	0	137.2	55.1	12.9	6.6	
43	8.2	12.2	1.0	0.0	0	116.4	17.1	13.2	6.6	Single phase (only 1-12 phase)
44	8.3	12.0	1.0	3.5	0	128.4	32.4	13.0	6.6	1-12 Phase, α -Fe

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Figure 14A

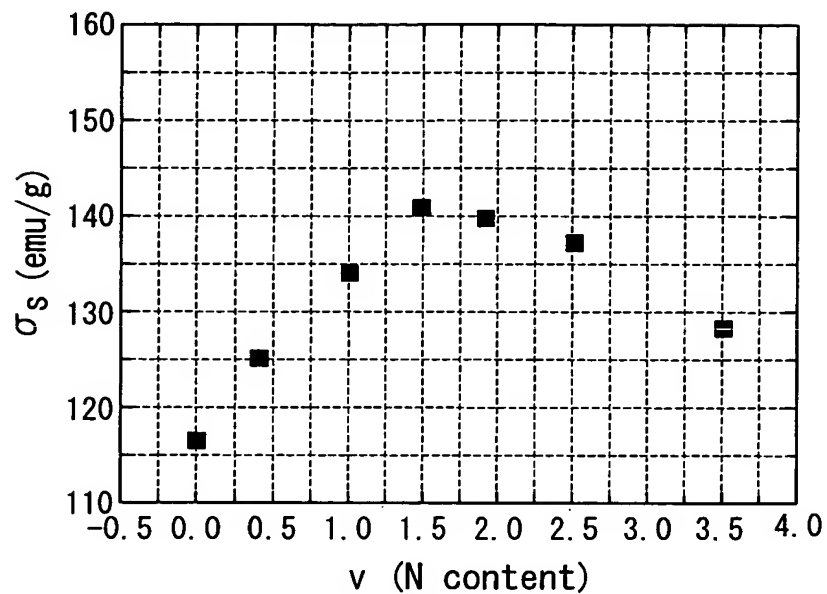
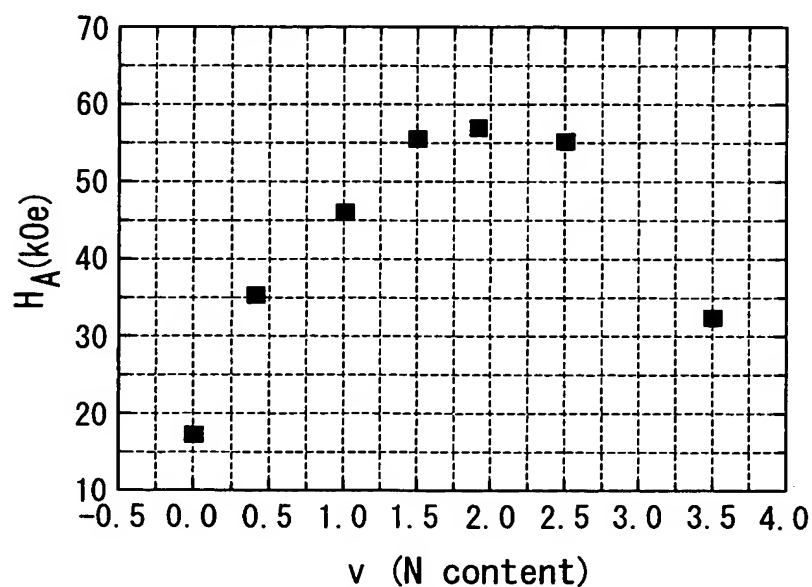


Figure 14B



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Figure 15

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
45	8.2	12.1	0.25	1.6	9.1	155.2	54.1	12.4	7.9	Single phase (only 1-12 phase)
46	8.1	12.0	0.25	1.5	18.2	161.5	56.3	12.3	7.9	
47	8.1	12.0	0.25	1.7	27.3	159.3	54.5	12.3	7.9	
48	8.2	12.0	1.0	1.5	9.1	148.3	57.2	13.0	6.6	
49	8.1	12.0	1.0	1.6	18.2	152.7	59.6	13.0	6.6	
50	8.1	12.0	1.0	1.5	27.3	149.3	58.6	13.0	6.6	

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Figure 16

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	C (v)	Co (w)	σ s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	Phases
51	8.2	12.1	0.25	1.5	0	140.2	43.5	12.4	7.9	Single phase (only 1-12 phase)
52	8.3	12.2	1.0	1.5	0	138.5	44.8	13.2	6.6	
53	8.3	12.0	2.0	1.5	0	132.6	38.5	14.0	4.9	
54	8.2	12.2	0.25	1.5	19.2	152.3	47.5	12.5	7.9	
55	8.2	12.0	0.25	2.0	0	138.6	41.3	12.3	7.9	
56	8.3	12.1	1.0	2.0	0	135.2	42.9	13.1	6.6	
57	8.2	12.1	2.0	2.0	0	129.5	37.1	14.1	4.9	
58	8.3	12.0	0.25	2.0	18.3	150.9	45.5	12.3	7.9	
59	8.2	12.2	1.0	0	0	116.4	17.1	13.2	6.6	

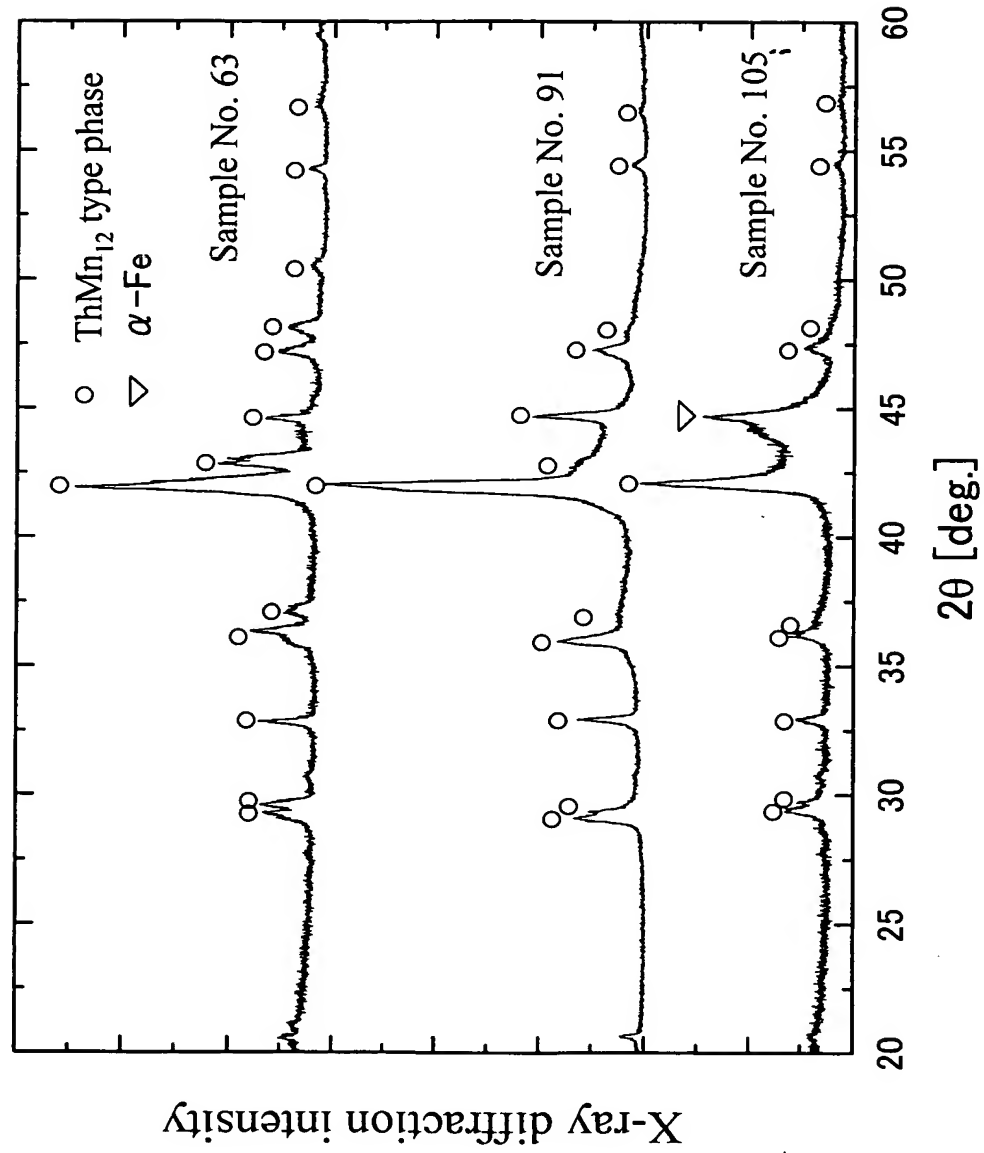
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Figure 17

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
60	0.00	8.3	12.0	1.0	2.3	0	139.4	56.2	13.0	Single phase (only 1-12 phase)
61	0.02	8.2	12.1	1.0	1.7	0	142.2	55.8	13.1	
62	0.04	8.2	12.0	0.9	1.8	0	144.6	55.0	12.9	
63	0.05	8.2	12.2	0.9	1.6	0	145.6	55.1	13.1	
64	0.06	8.2	12.1	1.0	1.6	0	144.5	55.1	13.1	
65	0.08	8.2	11.8	1.0	1.7	0	143.9	55.4	12.8	
66	0.10	8.3	12.0	0.9	1.6	0	142.5	53.9	12.9	
67	0.15	8.2	11.9	1.0	1.7	0	141.0	53.2	12.9	1-12 Phase, α -Fe Phase
68	0.20	8.2	11.9	1.0	2.2	0	139.1	52.9	12.9	

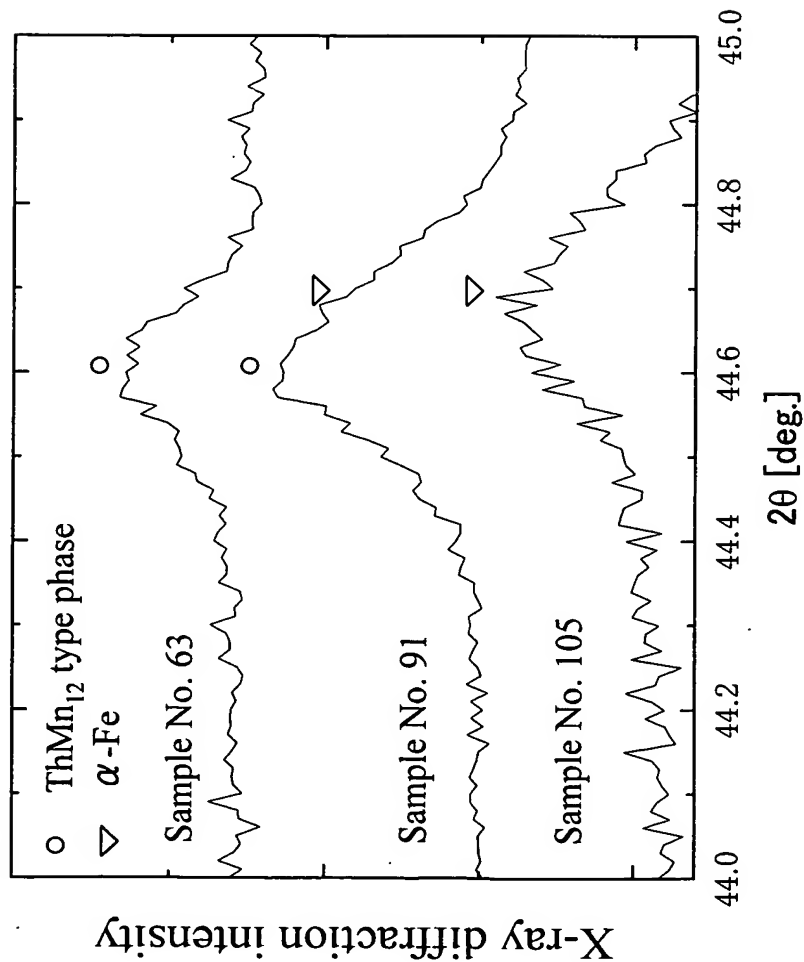
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Figure 18



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Figure 19



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Figure 20

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
69	0.05	8.3	12.1	0.0	1.4	0	142.1	28.9	12.1	1-12 Phase, 2-17 phase, α -Fe phase
70	0.05	8.3	11.9	0.2	1.6	0	148.8	51.5	12.1	Single phase (only 1-12 phase)
71	0.05	8.2	11.9	0.5	1.5	0	148.5	52.1	12.4	
72	0.05	8.2	12.0	1.5	1.3	0	143.2	58.2	13.5	
73	0.05	8.1	11.9	2.0	1.4	0	141.8	59.8	13.9	
74	0.05	8.3	12.1	2.5	1.4	0	134.7	35.7	14.6	1-12 Phase, α -Fe Phase

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Figure 21

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
75	0.05	8.2	11.5	0.5	1.8	0	144.9	49.5	12.0	1-12 Phase, NdN phase
76	0.05	8.3	11.9	0.5	1.5	0	148.5	52.1	12.4	Single phase (only 1-12 phase)
77	0.05	8.2	12.5	0.5	1.6	0	151.4	51.8	13.0	1-12 Phase, α -Fe Phase
78	0.05	8.0	11.1	1.0	1.6	0	140.2	54.6	12.1	1-12 Phase, NdN phase
79	0.05	8.3	12.2	1.0	1.5	0	147.7	55.1	13.2	Single phase (only 1-12 phase)
80	0.05	8.3	12.5	1.0	1.5	0	150.8	54.9	13.5	1-12 Phase, α -Fe Phase
81	0.05	8.2	10.5	0.5	1.5	0	135.2	35.1	11.0	Single phase (only 1-12 phase)
82	0.05	8.3	11.1	0.5	1.6	0	140.2	37.5	11.6	
83	0.05	8.3	10.0	1.0	1.4	0	128.7	37.4	11.0	
84	0.05	8.2	10.5	1.0	1.5	0	132.5	39.7	11.5	
85	0.05	8.3	13.0	1.0	1.6	0	148.5	35.8	14.0	1-12 Phase, α -Fe Phase
86	0.05	8.3	10.0	1.5	1.6	0	124.2	36.2	11.5	1-12 Phase, 2-17 phase, α -Fe phase

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Figure 22

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
87	0.05	6.6	12.1	1.0	1.3	0	150.5	57.1	13.1	Single phase (only 1-12 phase)
88	0.05	7.5	12.1	1.0	1.5	0	149.1	57.0	13.1	
89	0.05	10.0	11.9	1.0	1.5	0	140.2	50.3	12.9	
90	0.05	12.5	12.2	1.0	1.4	0	123.1	44.1	13.2	
91	0.05	5.8	12.2	1.5	1.4	0	152.4	62.0	13.7	1-12 Phase, α -Fe Phase
92	0.05	6.7	12.0	1.5	1.4	0	147.6	61.8	13.5	Single phase (only 1-12 phase)
93	0.05	7.5	11.9	1.5	1.5	0	146.0	60.4	13.4	
94	0.05	4.2	12.0	1.5	1.5	0	129.2	29.5	13.5	1-12 Phase, α -Fe Phase
95	0.05	5.0	11.9	2.0	1.4	0	147.5	63.8	13.9	Single phase (only 1-12 phase)
96	0.05	5.8	12.1	2.0	1.4	0	147.0	63.0	14.1	
97	0.05	6.7	12.0	2.0	1.5	0	147.3	62.8	14.0	
98	0.05	7.5	11.9	2.0	1.5	0	145.2	61.1	13.9	
99	0.05	3.3	12.1	2.0	1.5	0	138.5	45.3	14.1	1-12 Phase, 2-17 phase, α -Fe phase

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Figure 23

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
100	0.05	8.2	12.2	1.0	0.0	0	116.1	17.1	13.2	Single phase (only 1-12 phase)
101	0.05	8.3	12.2	1.1	0.4	0	130.2	35.2	13.3	
102	0.05	8.2	12.0	1.1	1.0	0	141.7	45.9	13.1	
103	0.05	8.2	11.9	1.0	1.9	0	144.2	56.8	12.9	
104	0.05	8.1	11.9	1.0	2.5	0	142.8	55.1	12.9	
105	0.05	8.3	12.0	1.0	3.5	0	134.2	32.4	13.0	1-12 Phase, NdN phase, α -Fe phase

Figure 24

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	N (v)	Co (w)	σ s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
106	0.05	8.2	12.1	0.25	1.6	9.1	160.5	54.1	12.4	Single phase (only 1-12 phase)
107	0.05	8.1	12.0	0.25	1.5	18.2	166.2	56.3	12.3	
108	0.05	8.1	12.0	0.25	1.7	27.3	164.5	54.5	12.3	
109	0.05	8.2	12.0	1.0	1.5	9.1	153.4	57.2	13.0	
110	0.05	8.1	12.0	1.0	1.6	18.2	157.4	59.6	13.0	
111	0.05	8.1	12.0	1.0	1.5	27.3	154.9	58.6	13.0	

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Figure 25

Sample No.	Zr (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	C (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
112	0.05	8.2	12.1	0.25	1.5	0	145.2	43.5	12.4	Single phase (only 1-12 phase)
113	0.05	8.3	12.2	1	1.5	0	143.2	44.8	13.2	
114	0.05	8.2	12.2	0.25	1.5	19.2	157.0	47.5	12.5	1-12 Phase, α -Fe Phase
115	0.05	8.2	12.0	0.25	2.0	0	143.5	41.3	12.3	Single phase (only 1-12 phase)
116	0.05	8.3	12.1	1	2.0	0	140.1	42.9	13.1	
117	0.05	8.3	12.0	0.25	2.0	18.3	156.0	49.2	12.3	

Figure 26

Sample No.	Hf (u)	Ti (y)	Fe+Co+Ti (x)	Si (z)	C (v)	Co (w)	σ_s [emu/g]	HA [kOe]	Fe+Co+Ti+Si (x+z)	Phases
118	0.02	8.2	11.9	1.0	1.7	0	140.5	53.1	12.9	Single phase (only 1-12 phase)
119	0.05	8.2	12.0	0.9	1.7	0	144.2	52.0	12.9	
120	0.10	8.3	11.9	1.0	1.8	0	141.1	53.5	12.9	

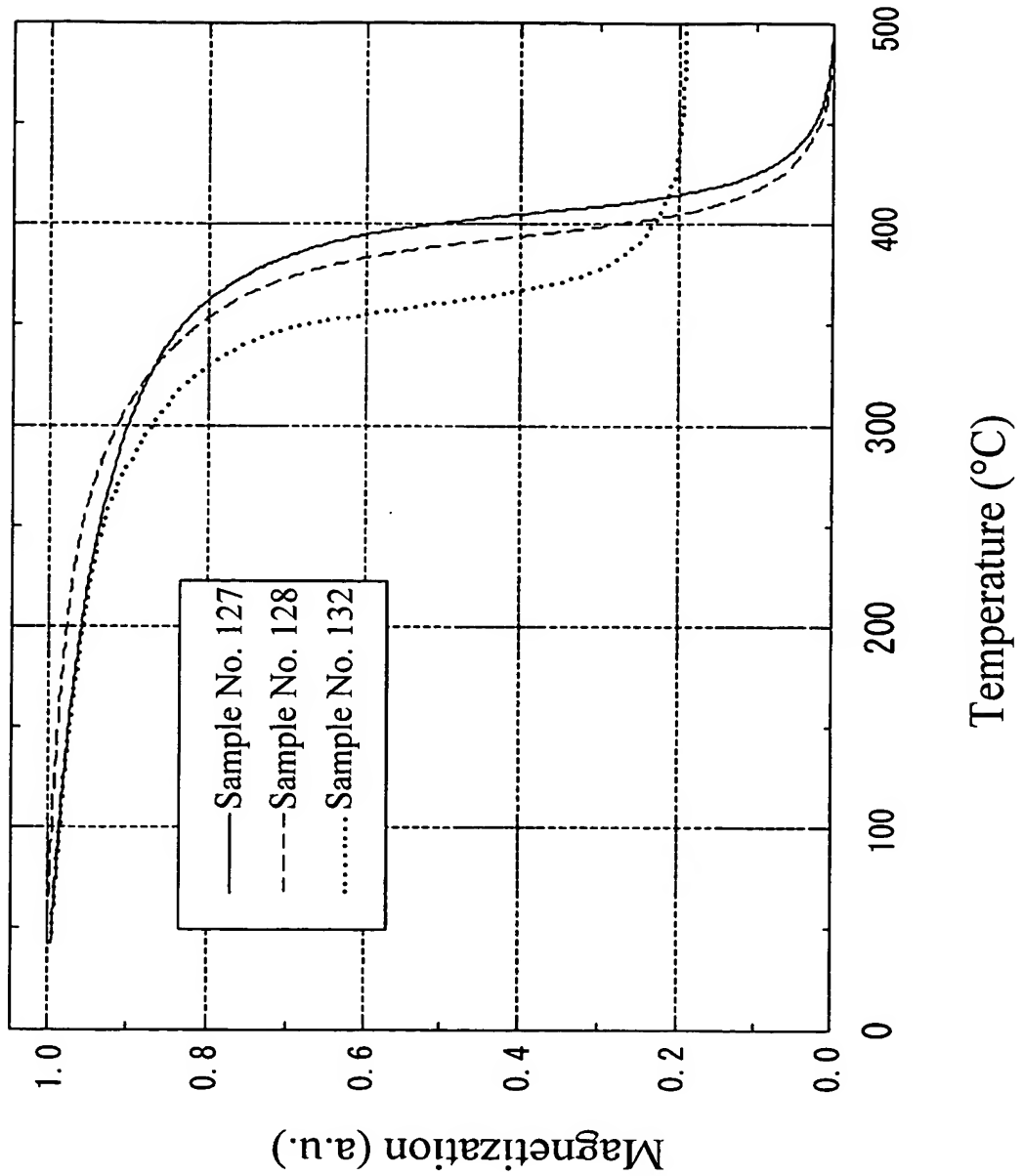
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Figure 27

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	σ_s [emu/g]	HA [kOe]	c/a	T _c (°C)	Phases
121	8.2	11.9	0.25	1.5	144.1	51.7	0.559	441	Single phase (only 1-12 phase)
122			0.50		143.5	52.1	0.561	438	
123			1.00		138.8	55.1	0.562	433	
124			1.50		138.0	58.1	0.562	433	
125			2.00		135.9	59.0	0.562	431	
126			2.50		129.5	40.7	0.561	467	
127	8.3	12.0	0.50	1.0	137.0	44.1	0.560	426	1-12 Phase, α -Fe
128			1.50	1.1	132.8	49.7	0.561	412	
129	8.2	11.9	—	1.5	138.2	28.1	0.552	442	
130			1.50	—	115.3	20.2	—	269	
131			3.00	1.5	123.2	27.1	0.556	467	
132	8.3	12.0	3.05	0.7	125.1	21.5	—	389	

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Figure 28



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Figure 29

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	σ_s [emu/g]	HA [kOe]	Fe+Ti+Si (x+z)	c/a	Phases
133	8.2	10.1	2.0	1.6	121.6	57.4	12.1	0.562	Single phase (only 1-12 phase)
134	8.1	10.5	1.9	1.5	124.8	59.0	12.4	0.562	
135	8.1	10.9	1.9	1.5	127.4	58.6	12.8	0.562	
136	8.0	12.2	2.0	1.4	135.9	58.9	14.2	0.561	
137	8.2	12.5	2.0	1.5	138.2	58.4	14.5	0.561	
138	8.3	12.7	2.0	1.6	137.8	45.8	14.7	-	1-12 Phase, α -Fe

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Figure 30

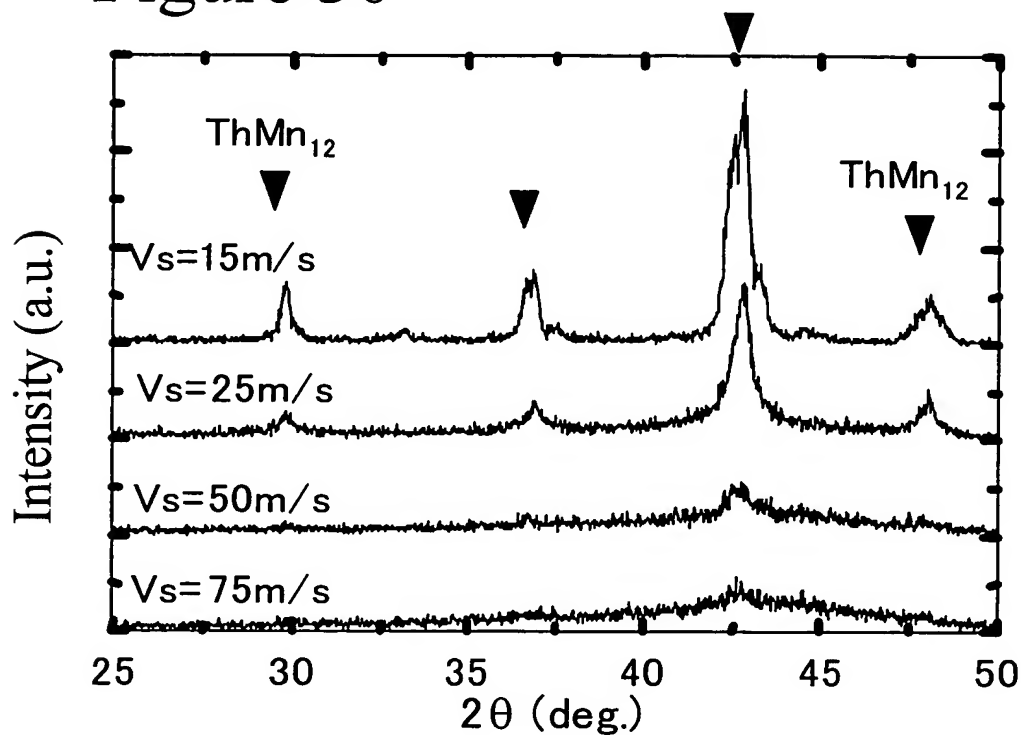
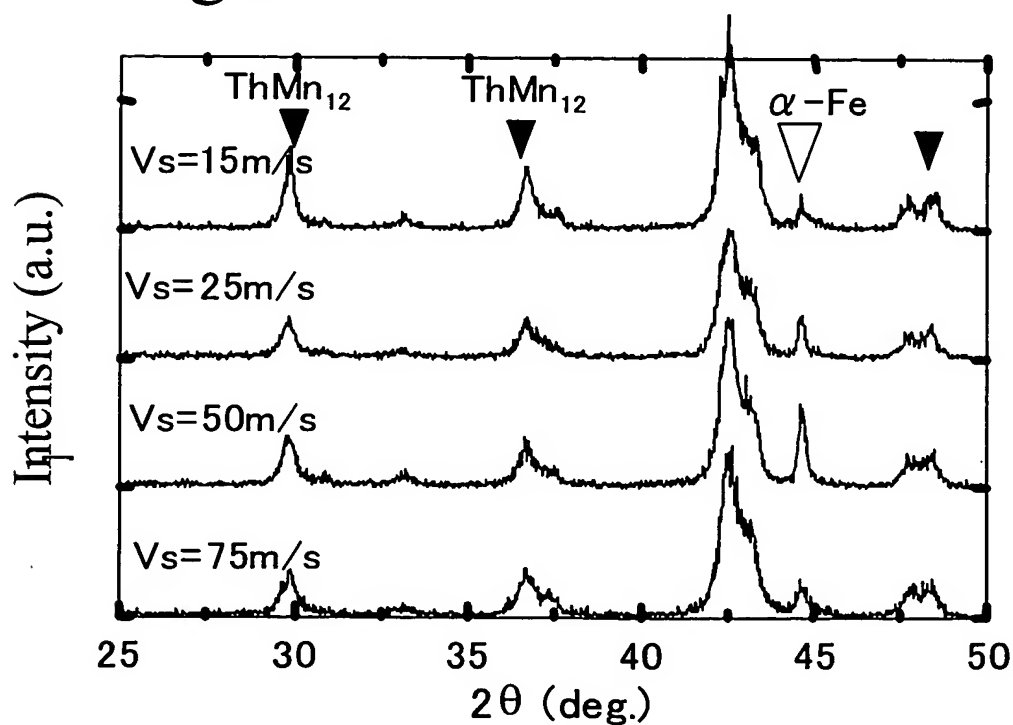
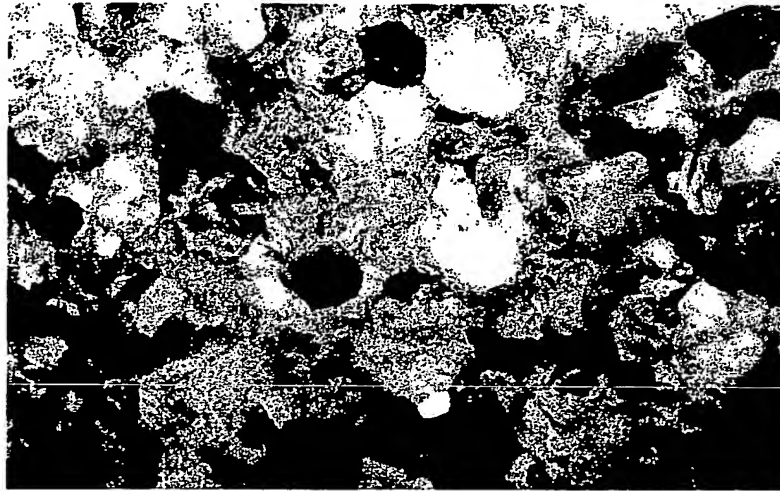


Figure 31



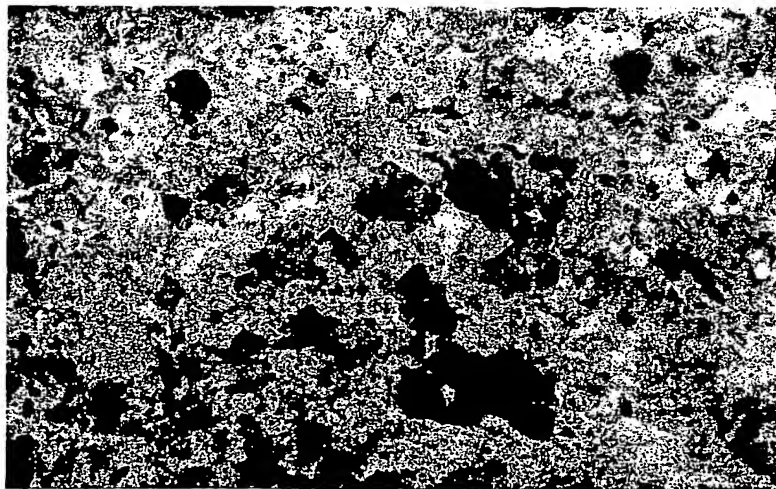
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Figure 32



50nm

Figure 33



50nm

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Figure 34

	Roll peripheral velocity (m/s)	Step	σ_r (emu/g)	H _{cj} (Oe)
Present invention	15	After quenching	26	500
		After heat treatment	31	620
		After nitriding	36	2,150
	25	After quenching	12	120
		After heat treatment	44	920
		After nitriding	86	7,920
	50	After quenching	12	80
		After heat treatment	45	980
		After nitriding	88	8,100
	75	After quenching	8	80
		After heat treatment	51	1,010
		After nitriding	84	7,860
Comparative example	Cast alloy	After casting	10	120
		—		
		After nitriding	24	400

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Figure 35

Sample No.	Ti (y)	Fe+Ti (x)	Si (z)	N (v)	Co (w)	Fe+Ti+Si (x+z)	Lower limit for Ti 8.3-1.7z	σ_r [emu/g]	H _{cj} (Oe)
139	8.3	11.9	0.2	1.6	0	12.1	8.0	79	5,880
140	8.1	11.9	2.0	1.4	0	13.9	4.9	75	7,900
141	8.0	11.2	1.0	1.6	0	12.2	6.6	72	6,600
142	8.2	10.1	2.0	1.6	0	12.1	4.9	67	7,300
143	8.2	12.5	2.0	1.5	0	14.5	4.9	76	7,560
144	6.6	12.1	1.0	1.3	0	13.1	6.6	80	7,220
145	6.7	12.0	1.5	1.4	0	13.5	5.8	79	8,470
146	6.7	12.0	2.0	1.5	0	14.0	4.9	78	8,750
147	8.3	12.2	1.1	0.4	0	13.3	6.4	69	2,750
148	8.1	11.9	1.0	2.5	0	12.9	6.6	76	6,730
149	8.2	12.1	0.3	1.5	0	12.4	7.9	77	4,200
150	8.3	12.0	2.0	1.5	0	14.0	4.9	73	3,300
151	8.2	12.2	0.3	1.5	19.2	12.5	7.9	84	5,000
152	8.3	12.0	0.3	2.0	18.3	12.3	7.9	83	4,590
153	8.3	12.1	0	1.4	0	12.1	8.3	32	600
154	8.3	12.1	2.5	1.4	0	14.6	4.1	29	800